PATENT SPECIFICATION

DRAWINGS ATTACHED

1,085,949

1,085,949

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Date of filing Complete Specification: Jan. 22, 1965

Application Date: Dec. 18, 1963. *No. 49896/63.*

Complete Specification Published: Oct. 4, 1967.

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Index at acceptance:—B5 B(21D1, 21F, 22B, 23B)

Int. Cl.:—B 29 d 7/08

COMPLETE SPECIFICATION

Improvements in and relating to Films of Thermoplastic Material

We, T. J. SMITH & NEPHEW LIMITED, a British Company, of Neptune Street, Hull, Yorkshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to films of thermoplastic material formed by continuously extruding the material in a molten state as a flat thin wide mass or layer, and particularly to a treatment applied to such material between its actual emergence from a slit die of described dimensions as an extrusion, and the "setting" to form a film, whereby when said flat thin wide mass or layer is in a more or less semi-molten state and before it sets to form a film or sheet, said flat thin wide mass or layer of material is subjected to a perforating action so that when the perforated material subsequently sets it sets as an already perforated film, which film had no existence in the unperforated condition.

According to the present invention, the method for perforating the flat thin wide mass or layer of more or less semi-molten thermoplastic material, is to extrude it from the slit die on to a moving supporting surface of a movable member which moves with the extruded material and at the same speed, this supporting surface being indented or perforated, and, while so moving and supported to expose the semi-molten mass or layer or a desired short period, to the heating action of a flame or flames — preferably by the tip portions of said flames making contact with the outer surfaces of the mass or layer — which have a temperature at least equal to but preferably much greater than the melting point of the thermoplastic material.

This has the effect of re-melting the semi-molten thermoplastic mass or layer in the positions which coincide with the depressions in the indented surface or with the perforations in the supporting and moving member having such surface, but leaving the portions of said mass or layer, the under surface of which makes contact with the surface of the movable supporting member, unmelted, so that when, in the continuous action, the thus-perforated flat thin wide mass or layer is stripped or separated from the indented or perforated surface, to pass to other supporting means it can ultimately set to form a film already having perforations therein. Alternatively, the perforated layer could be cooled completely on the indented or perforated surface.

In order that the invention may be better understood, it will now be described with reference to the accompanying diagrammatic drawings which are given by way of example only and in which:—

Fig. 1 is a diagrammatic fragmentary sectional elevation showing one embodiment of the method of carrying the invention into effect.

Fig. 2 is a like view, showing another embodiment of the method of the invention, very similar to that of Fig. 1.

Fig. 3 is a greatly enlarged sectional diagram of a portion of the indented roller of Figs. 1 and 2 straightened out to illustrate the perforating action, and

Fig. 4 is an enlarged view of an example of a portion of a thin mass or layer of the semi-molten thermoplastic material after it has been perforated, and then set, to form a film having perforations therein but *not* a film which has been perforated.

In the method of carrying the invention into effect as shown in Fig. 1 5 is a hollow metal cylinder kept at a desired working temperature above that of the surrounding atmosphere having an outer surface with indentations 6 (shown much larger than full size) arranged according to any desired pattern, which may be a regular pattern with the indentations uniformly arranged therein.

On to this surface a thin mass or layer 7 of the thermoplastic material is extruded

[*Pri*

in a molten state from an extruder with an elongated slit die 8.

The speed of extrusion of the molten material is synchronised with the linear speed of the surface of the roller, and the molten thermoplastic material 7 passes through a desired angular distance from the extruder in contact with and at the same speed as the indented surface of the roller 5, to the zone of a fixed burner 9. During this movement the molten state of the material gradually changes to what may be termed an approximately semi-molten condition. The burner 9 provides a row of closely positioned flames 10 arranged in a plane (the end one only of which appears on the drawing) so positioned that the tips of the flames are caused to impinge on the outer surface of the mass of material 7 as it passes by.

The arrangement is such that the heating action is for only a short period, which may be a small fraction of a second, depending, amongst other factors, on the linear speed of the material, the thickness of the mass or layer of the material, and the temperature at the tips of the flames, which must be higher than the melting point of the thermoplastic material and may, for instance if desired, be 1200°C or even higher.

The enlarged diagrammatic view of Fig. 3 illustrates the action of forming the perforations by re-melting the portions of the thermoplastic mass which are positioned over the indentations 6 on the roller 5.

The roller 5 and molten material 7 carried thereby moves in the direction of the arrow 11, to and beyond the flame 10 which has a temperature T which is above that of the melting point of the material leaving the extruder in the molten condition and arriving at the flame in a semi-molten condition.

This material 7 (to the left-hand side of the flame 10 in Fig. 3) which contacts and lies on the surface of the roller, rapidly has the heat therein conducted away to the mass of the roller, the high degree of conductivity being represented by the arrows C. As a result, this material contacting the surface of the roller, has its temperature reduced to *h*.

In contrast to this, the material 7 above the indentations 6, has less heat (per unit volume) conducted away, and is represented by the arrows *c*, owing to the relatively lower conductivity of the air in the indentations as compared with that of the metal of the roller. As a result, the material above the indentations has its temperature reduced a lesser amount, and actually has a temperature H which is higher than *h*.

When arriving at the flame 10, the heat at a temperature T imparted to the material 7, is conducted away at the roller contacting portions with the high degree of conductivity C, and at the indented portions with the low degree of conductivity *c*.

In the result, in the short passing period (which may be a small fraction of a second) the amount of heat imparted from the flame 10 to and retained by the roller-supported semi-molten portions of the material which have a temperature *h*, is insufficient to remelt these portions, whilst the heat imparted from the flame 10 to and retained by the semi-molten portions of material above the indentations, which have a temperature H, is sufficient to re-melt these portions, to leave perforations such as 12 in these positions.

The semi-molten material 7, thus perforated, passes on with and by the movement of the roller, to driven take-off rollers 13 and 14 and thence to a fixed supporting table or the like 15. It gradually cools and finally sets, and at that moment a film of thermoplastic material is formed having perforations therein.

It is desired here to emphasise that this is a different product, having many different characteristics, from a set film of thermoplastic material which, as an unperforated film, has perforations made therein by similar heating.

In some cases the heating flame or flames may be replaced by a jet or jets of heated air or other inert gas having an operating temperature similar to that of the flames.

Again, the flaming or like method, as used in the present invention, when applied to already-completed unorientated films of thermoplastic material, is not satisfactory, as when the unperforated unorientated film is applied on to the indented or perforated roller, the working temperature of which is above room temperature, this working temperature causes the film to expand laterally before it attains the flaming zone.

This lateral expansion results in the formation of wrinkles which are subsequently melted away by the flaming action, virtually slitting the film longitudinally at the location of said wrinkles.

The present invention, however, does not have this defect, but has the advantage, that the extruded, more or less semi-molten hot and unset thermoplastic material does not expand laterally (due to the working temperature of the indented or perforated roller) on contacting and being laid on said roller, but passes to the heat-treating zone without the formation of wrinkles due to such expansion, so that the heat effects the perforating in a satisfactory manner and as hereinbefore set forth.

The indentations in the supporting surface, for example of a roller, or in other cases, for instance, of an endless band of metal, could be of any desired shape, for example circular or oval, and with any desired dimensions, which could be 0.010″ wide, 0.020″ long, and 0.004/0.005″ deep. These indentations can be arranged in staggered rows on the roller, both circumferentially and longitudinally at desired spacing. As an example a highly enlarged portion of a film having perforations, made according to the invention, is shown in Fig. 4.

Although the temperature of the flame at the point of contact with the surface of the film can be, as previously explained, as high as 1200°C. it may sometimes be higher. For example, it could have the normal temperature of gas flames, which is within the region of 1400°C to 1700°C.

Fig. 2 shows a method of carrying the invention into effect, the same as shown in Fig. 1 except tht the extruder 8 delivers the molten flat layer or mass 7 of thermoplastic material on to the upper run of an endless band 16 operating between two heated driving rollers 17 and 18 whose speed is synchronised with that of the extrusion and the linear speed of the surface of the roller 5. After leaving the upper run of the band 16, the molten material passes over a heated bridging member 19 from which it is tangentially fed to the surface of the roller 5.

In some cases there may also be included an upper driven heated roller 20 above the roller 18, to give a slight "nip" to the almost molten material as it passes and to reduce its thickness.

Where an endless band of steel or other metal is employed as the support for the extruded molten material, it has the desired pattern of indentations or perforations and passes around suitably arranged rollers which are heated to keep the band at a required working temperature. In the position where this band supports the flat thin wide semi-molten mass or layer to be perforated, it passes over a table which could be hollow and maintained at a required temperature to assist in keeping the band at its working temperature.

The pattern of indentations on the curved metal surface of metal band, may be produced in any suitable manner according to the nature, size and spacing of the pattern. In many cases the indentations may be etched by any known etching process suitable for the purpose. Thus, there is no difficulty in producing a pattern of closely spaced small shallow indentations, but it should be understood that the invention is applicable to cases where the perforations are much larger and more widely spaced.

The perforated semi-molten mass, when it has had the perforations made therein by re-melting the portions of the mass above the indentations or perforations in the roller or the like, may pass, while still hot, to a biaxial stretching apparatus or portion of a combined machine.

In this biaxial stretching process, not only will the perforations be enlarged, but the material will be reduced in thickness in proportion to the expansion given to its area. Thereafter, the cooling-down could be effected and the heated mass allowed to set to form the film with the perforations therein.

WHAT WE CLAIM IS:—

1. A method for forming a set film of thermoplastic material having a desired pattern of perforations therein, comprising extruding the thermoplastic material in a molten condition from an elongated slit die on to a moving supporting surface of a movable member which moves with and at the same speed as the extruded material, this supporting surface being indented or perforated with a desired pattern of indentations or perforations, and when in such movement the molten material has changed to an approximately semi-molten condition and whilst continuing to move, exposing the semi-molten mass or layer for a desired short period to the heating action of a flame or flames — preferably by the tip portions of said flames making contact with the outer surface of the mass or layer — which have a temperature at least equal to but preferably much greater than the melting point of the thermoplastic mass or layer in the positions over the indentations or perforations, to form perforations in said semi-molten mass or layer but to leave the portions of said mass or layer — the under surface of which makes contact with the surface of the movable supporting member — unmelted, the thus-perforated mass or layer then being cooled to set and form a film having a pattern of perforations therein.

2. A method for forming a set film of thermoplastic material having a desired pattern of perforations therein, as claimed in claim 1, in which the flames to re-melt the semi-molten material coming above the indentations or perforations, are replaced by a jet or jets of heated air or other inert gas at a temperature corresponding to that of the flames.

3. A method for forming a set film of thermoplastic material having a desired pattern of perforations therein, as claimed in claim 1 or 2, in which the supporting surface with the indentations or perforations is heated to a desired working temperature above the temperature of the surrounding atmosphere, to bring the material in a semi-molten state to the heat treating position.

4. A method for forming a set film of thermoplastic material having a desired pattern of perforations therein, as claimed in claim 1, 2 or 3, in which the supporting surface is a roller with indentations on its outer surface, or a hollow roller with perforations through its outer curved wall.

5. A method for forming a set film of thermoplastic material having a desired pattern of perforations therein, as claimed in claim 1, 2 or 3, in which the supporting surface is an endless band with indentations on its working surface or perforations through said band.

6. A method for forming a set film of thermoplastic material having a desired pattern of perforations therein, as claimed in any one of the preceding claims, in which the thin layer or mass of thermoplastic material after being perforated, whilst still hot and before

setting, is subjected to a biaxial stretching and is then allowed to cool and set.

7. Thermoplastic films with perforations therein, whenever formed by any of the methods claimed in any one of the preceding claims.

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Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1967. Published by The Patent Office, 25 Southampton Buildings, London, W.C.2. from which copies may be obtained.

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1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

Fig. 4.

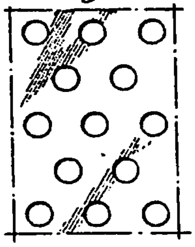


Fig. 1.

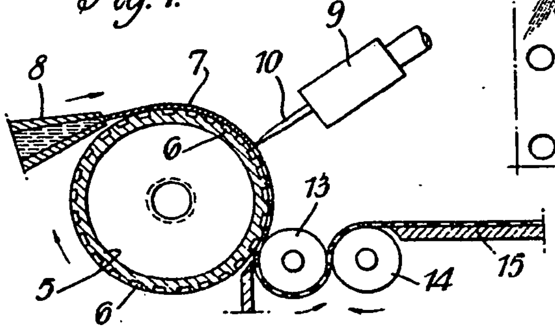


Fig. 2.

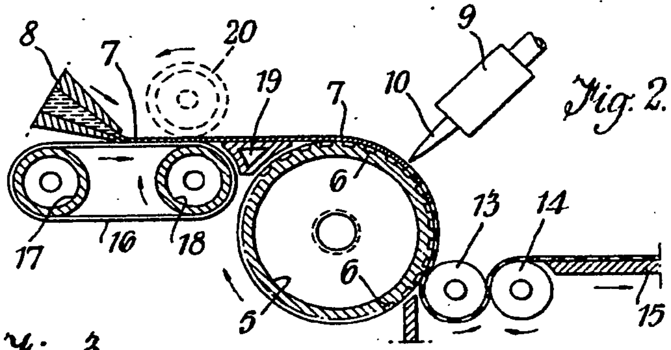
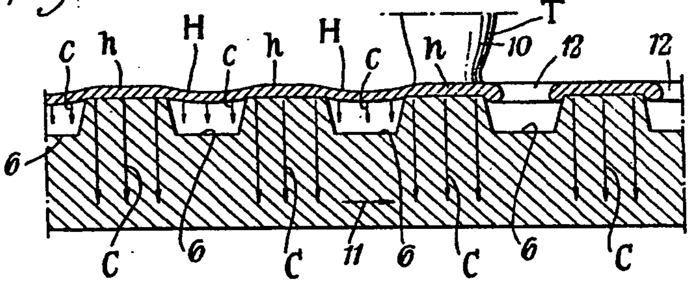


Fig. 3.



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